1.1. SYNTHESIS OF CHEMICAL FORMULAE

In this section you will apply the concept of moles and percentage composition by mass of a substance contained in the formulae. These formulae include: -

Empirical formula (E.f) Is the simplest possible formula of a compound.

Molecular formula (M.f) Is that formula which shows the actual number of different atoms present in the molecule.

Alkane	(M.f)	(E.f)	Alcohol	(M.f)	(E.f)
Methane	CH_4	CH_4	Methanol	CH_3OH	CH_4O
Ethane	C_2H_6	CH_3	Ethanol	C_2H_5OH	C_2H_6O
Propane	C_3H_8	C_3H_8	Propanol	C_3H_7OH	C_3H_8O
Butane	C_4H_{10}	C_2H_5	Butanol	C_4H_9OH	$C_4H_{10}O$

Molecular formula (**M.f**) = (Empirical formula, E.f)n

$$n = \frac{RFM}{E.f}$$ Also RFM = (Vapour density) x2

Footnote: If the result from the Empirical formulae don't approximate to whole numbers, then multiply them by 2 (for 1.5, 2.5) to give the whole numbers as (3, 5).

Worked out example 11:

A hydrated salt X contains 20.2% iron, 11.5% Sulphur, 23% oxygen and 45.3% water of crystallization.

a) Calculate the empirical formula of X. (Ar of: Fe =56, S =32, O =16, H =1)
b) Deduce the molecular formula of X (Relative formula mass of X = 278)

Possible answer for part (a)

Element	Iron	Sulphur	Oxygen	Water of crystallization
Symbol	**Fe**	**S**	**O**	**H_2O**
Composition	20.2	11.5	23	45.3
Number of moles	$\frac{20.2}{56}$ **= 0.360**	$\frac{11.5}{32}$ **= 0.359**	$\frac{23}{16}$ **= 1.4375**	$\frac{45.3}{18}$ **= 2.517**
Mole ratio	$\frac{0.360}{0.359}$ **= 1**	$\frac{0.0359}{0.359}$ **= 1**	$\frac{1.4375}{0.359}$ **= 4**	$\frac{2.517}{0.359}$ **= 7**
Empirical formula of X = $FeSO_4.7H_2O$				

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Possible answer for part (b)

M.f = (Empirical formula) n = RFM •

M.f= (**$FeSO_4.7H_2O$**) n = 278

M.f = (56x1) + [(32x1) +(16x4) +(18x7)] n = 278

M.f = 278n = 278, = ($\frac{278}{278}$) n =1 Therefore, **M.f** of X is **$FeSO_4.7H_2O$**

Worked out example 12:

A gaseous organic compound **W** contains 82.76% carbon, the rest being hydrogen.

a) Calculate the empirical formula of W.
b) 140cm^3 of W weighed 0.363g at **s.t.p**. Determine the molecular formula of W. (**1 mole of a gas occupies 22400cm^3 at s.t.p, Ar of: C =12, H =1**)

Possible answer for part (a)

Element	**Carbon**	**Hydrogen**
Symbol	**C**	**H**
Composition	82.76	17.24
Moles of atoms	$\frac{82.76}{12}$ **= 6.897**	$\frac{17.24}{1}$ **= 17.24**
Mole ratio	$\frac{6.897}{6.897}$ **= 1** **1x2 =2**	$\frac{17.24}{6.897}$ **= 2.5** **2.5x2 = 5**
Empirical formula of W is C_2H_5		

Possible answer for part (b)

M.f = (Empirical formula) n = RFM, so

140cm^3 of W weighs 0.363g.

22400cm^3 of W weigh $\frac{14o\ x0.363}{22400}$

Therefore, RFM = 58.08.

M.f = (C_2H_5) n = 58.08

= (12x2 + 1x5) n 58.08

($\frac{58.08}{29}$) n = 2

M.f of W= **C_4H_{10}**

ACTIVITY: 3.5(a) Synthesis of chemical formulae of compounds.

What to do: In groups

Discuss how the empirical formulae (**E.f**) and molecular formulae (**M.f**) of the following compounds can be calculated. Share and compare your findings with the rest of the class.

Discussion Questions:

1. A compound **Z** of molecular formula **$A_xB_y.nH_2O$** consists of 8.57% A, 45.71% B and 45.72% water of crystallization.
   a) Determine the values of x, y and n and hence write the molecular formula of Z. (**Ar of: A =27, B = 96, H =1, O =16**)

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2. A gaseous hydrocarbon **X** contains 20% hydrogen by mass. 7.5g of X occupy 5.6 dm^3 at s.t.p. Calculate the:
   a) Empirical formula of X (**Ar of: C =12, H =1)**
   b) Relative formula mass of X
   c) Molecular formula of X.
3. Compound **T** contains 40% carbon, 6.7% hydrogen and the rest being oxygen. The relative formula mass of T is 60. (**Ar of: C =12, H =1, O =16**)
   a) Calculate the empirical formula of T.
   b) Determine the molecular formula of T.
4. A hydrated carbonate of the formula, **$Na_2CO_3.nH_2O$**, contains 62.9% water of crystallization and the being sodium carbonate. the relative molecular mass of the compound is **286**.
   a) Calculate the empirical formula of the compound.
   b) Determine the value of n, hence molecular formula of the compound.
   (**Ar of: Na =23, C =12. O =16. H =1**)
5. A gaseous hydrocarbon **T** contains 80% carbon and the rest being hydrogen. The molecular mass of T is 30. Calculate the:
   a) Empirical formula of T. (**Ar of: C =12, H =1**)
   b) Molecular formula of T
6. In a certain experiment, a compound was found to contain 72.0g of magnesium and 28.0g of nitrogen. The molecular mass of the compound is 100. Calculate the:
   a) Empirical formula of the compound. (**Ar of: Mg =24, N =14**)
   b) Molecular formula of the compound.
7. An organic compound **Z** contains 12.8% carbon, 2.1% hydrogen and 85.1% bromine. The molecular mass of Z is 188. Calculate the:
   a) Empirical formula of Z (**Ar of: C =12, H =1, Br =80**)
   b) Molecular formula of Z and hence molecular structure of Z.
8. A certain compound **H** contains 19.4% calcium, 34.3% chlorine, and 46.4% oxygen. The molar mass of **H** is 139.5. Calculate the:
   a) Empirical formula of H (**Ar of: Ca =40, Cl =35,5, O = 16**)
   b) Molecular formula of H.
9. An organic compound **R** consists of 57.82% carbon, 3.6% hydrogen, and the rest being oxygen. The vapour density of R is 83.
   a) Calculate the empirical formula of R
   b) Determine the molecular formula of R. (**Ar of: C =12, H =1, O =16)**
10. A compound **K** consists of 3.46g of Aluminium, 6.15g of oxygen and 0.38g of hydrogen. Calculate the empirical formula of K. (**Ar of Al =27, O =16, H =1**)

1.2. CHEMICAL EQUATIONS AND BALANCING

In this section, you will understand the skills and knowledge of writing and balancing chemical equations in our day – to – day life activities.

1.2.1. Chemical reactions of substances

Chemical reactions are represented by use of **chemical equations**. A successful chemical equation must have the following.

1. **Reactants**: Are mainly substances taking parts in a chemical reaction.
2. **Products:** Are mainly substances formed during a chemical reaction.
3. **States of matter:** Are mainly symbols such as (**aq**) for aqueous, (**s**) for solids, (**l**) for liquids and (**g**) for gases.
4. **Balancing equations:** This involves determining the number of atoms involved on both reactant hand side (**R.H.S**) and product hand side (**P.H.S**) of the equation.

Worked out example 12

Zinc carbonate was heated strongly in a test tube, until there was no further change. Zinc oxide, and carbon dioxide gas were formed.

Write a balanced equation for the reaction that took place.

Possible answer: **R.H.S** **P.H.S**

Word equation: **Zinc carbonate(s)** $\longrightarrow$ **Zinc oxide(s) + Carbon dioxide(g)**

Formula: $ZnCO_{3\,(s)} \longrightarrow ZnO_{(s)} + CO_{2\,(g)}$

No. of atoms: Zn =1 Zn =1

C =1 C =1

O =3 O =3

Balanced equation $\mathbf{ZnCO_{3\,(s)}} \longrightarrow \mathbf{ZnO_{(s)}} + \mathbf{CO_{2\,(g)}}$

No. of moles: 1 mole of $ZnCO_3$ produced 1 mole of ZnO and 1 mole of CO_2

Worked out example 13

Calcium carbonate reacts with dilute hydrochloric acid producing a colourless solution of calcium chloride, carbon dioxide gas and water. Write a balanced equation for the reaction that took place.

Possible answer: R.H.S **P.H.S**

Word equation: **Calcium Carbonate(s)** + **Hydrochloric acid (aq)** $\longrightarrow$ **Calcium chloride(aq)** + **Carbon dioxide (g)** + **Water (l)**

Formula: $\mathbf{CaCO_{3\,(s)}} + \mathbf{HCl_{(aq)}} \longrightarrow \mathbf{CaCl_{2\,(aq)}} + \mathbf{CO_{2\,(g)}} + H_2O_{(l)}$

No. of atoms: Ca =1 Ca =1

C= 1 C =1

O =3 O =3

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2x H =2	H =2
2x Cl =2	Cl =2

A balanced equation: $\mathbf{CaCO_{3\,(s)}} + \mathbf{2HCl_{(aq)}} \longrightarrow \mathbf{CaCl_{2\,(aq)}} + \mathbf{CO_{2\,(g)}} + H_2O_{(l)}$

Number of moles: 1 mole of **$CaCO_3$** reacts with 2 moles of **HCl** to produced 1 mole of **$CaCl_2$**, 1 mole of **CO_2** and 1 mole of **water molecule.**

ACTIVITY:3.6(a) To write molecular balanced chemical equations

What to do: In groups

Discuss on how each of the following "**word equations**" can be converted in to well-balanced chemical equations. Share and compare your findings with the rest of the class.

Discussion Questions:

1. Write a well – balanced equation for each of the following word equations. And in each case write the number of moles of both reactants and products.

a) Carbon(s) + Oxygen(g) ⟶ Carbon dioxide(g)
b) Magnesium oxide(s) + Carbon(s) ⟶ Magnesium (s) + Carbon dioxide(g)
c) Sodium(s) + Oxygen(g) ⟶ Sodium oxide(s)
d) Aluminium(s) + Oxygen(g) ⟶ Aluminium oxide(s)
e) Calcium(s) + Oxygen(g) ⟶ Calcium oxide(s)
f) Magnesium(s) + Nitrogen(g) ⟶ Magnesium nitride(s)
g) Zinc Carbonate(s) ⟶ Zinc Oxide(s) + Carbon dioxide(g)
h) Lead (II) carbonate(s) ⟶ Lead (II) oxide(s) + Carbon dioxide(g)
i) Copper (II) nitrate(s) ⟶ Copper (II) oxide(s) + Nitrogen dioxide(g) + Oxygen(g)
j) Lead (II) Nitrate(s) ⟶ Lead (II) oxide(s) + Nitrogen dioxide(g) + Oxygen(g)
k) Copper (II) Carbonate(s) + Sulphuric acid (aq) ⟶ Copper (II) sulphate(aq) + Carbon dioxide(g) + Water(l)
l) Sodium Carbonate(aq) + Hydrochloric acid(aq) ⟶ Sodium chloride(aq) + Carbon dioxide(g) + Water(l)
m) Sodium Carbonate(aq) + Copper (II) sulphate(aq) ⟶ Sodium sulphate(aq) + Copper (II) carbonate(s)
n) Copper (II) Sulphate(aq) + Sodium hydroxide(aq) ⟶ Copper (II) hydroxide(s) + Sodium sulphate(aq)
o) Zinc chloride(aq) + Sodium hydroxide(aq) ⟶ Zinc hydroxide(aq) + Sodium chloride(aq)
p) Ammonia(g) + Sulphuric acid(aq) ⟶ Ammonium sulphate(aq)
q) Ammonium chloride(s) ⟶ Ammonia(g) + Hydrogen chloride(g)

2. Write the correct balanced equations for following chemical reactions. Use only whole numbers when balancing equations where necessary.

a) $NH_4Cl_{(s)} \longrightarrow NH_{3(g)} + HCl_{(g)}$

b) $ZnCl_{2(aq)} + NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)} + NaCl_{(aq)}$

c) $CuSO_{4(aq)} + NaOH_{(aq)} \longrightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)}$

d) $Na_2CO_{3(aq)} + CuSO_{4(aq)} \longrightarrow CuCO_{3(s)} + Na_2SO_{4(aq)}$

e) $CuCO_{3(s} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$

f) $Na_2CO_{3(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)\ )} + H_2O_{(l)} + CO_{2(g)}$

g) $Mg_{(s)} + N_{2(g)} \longrightarrow \mathbf{Mg_3N_{2(s)}}$

h) $Pb(NO_3)_{2(s)} \longrightarrow PbO_{(s)} + NO_{2(g)} + O_{2(g)}$

i) $ZnCO_{3(s)} \longrightarrow ZnO_{(s)} + CO_{2(g)}$

j) $Cu(NO_3)_{2(s)} \longrightarrow CuO_{(s)} + NO_{2(g)} + O_{2(g)}$

k) $Ca_{(s)} + O_{2(g)} \longrightarrow CaO_{(s)}$

l) $KClO_{4(s)} \longrightarrow KCl_{(s)} + O_{2(g)}$

m) $H_2O_{2(aq)} \longrightarrow H_2O_{(l)} + O_{2(g)}$

n) $Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$

1.3. STOICHIOMETRY IN CALCULATIONS

Stoichiometry deals with the calculations of **volumes** and **masses** of reactants or products during chemical reactions. It involves determining quantitative amounts between a given reactant or a product in a well-balanced chemical equation.

1.3.1. Calculating gas volumes from balanced equations.

From any chemical equation for the reaction, one can give out how many ***moles*** of a gas that reacted or is produced during the chemical reaction

Worked out example 14.

1. What is the volume of hydrogen that reacted with 24dm^3 of oxygen to form water?

Possible answer:

Step1: A well balanced equation: $\mathbf{O_{2(g)} + 2H_{2(g)} \longrightarrow 2H_2O_{(l)}}$

Step2: Moles: 1 mole 2 moles 2 moles

Step3: Volume of a gas: 1 dm^3 2 dm^3 (excess)

Therefore, 1 dm^3 of oxygen reacts with 2 dm^3 of hydrogen

24dm^3 of oxygen react with (2 x 24) dm^3 = **48dm^3** of hydrogen.

2. Steam was passed over methane gas to form hydrogen gas and carbon dioxide gas. What volume of methane gas reacted with 20cm^{3}of steam?

Possible answer

Equation: $\mathbf{2H_2O_{(g)} + CH_{4(g)} \longrightarrow 4H_{2(g)} + CO_{2(g)}}$

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Moles 2moles 1 mole 4 moles 1 mole

Volumes: $2cm^3$ $1cm^3$ $4cm^3$ $1\ cm^3$

Therefore, $2cm^3$ of steam reacted with $1cm^3$ of methane gas.

$20cm^3$ of steam reacted with $\frac{1\ x\ 20}{2}$ cm^3 of methane gas

= **$10cm^3$ of methane gas.**

3. $20cm^3$of carbon monoxide gas was mixed $20cm^3$ of oxygen gas and exploded. What is the total volume of the final gaseous product formed?

Possible answer:

Equation: $\mathbf{2CO_{(g)} + O_{2\,(g)} \rightarrow 2CO_{2(g)}}$

Moles: 2 moles 1 mole 2 moles

2moles of CO reacts with 1mole of O_2

$20cm^3$ of CO react with $\frac{1\ x\ 20}{2}$ cm^3 of O_2

So, volume of unreacted $O_2 = 10cm^3$

2moles of CO produced 2moles of CO_2

$20cm^3$ of CO produced $\frac{2\ x\ 20}{2}cm^3$ of CO_2

= **$20cm^3$ of CO_2**

So, total final Vol of CO_2 =(10+20) = $30cm^3$

ACTIVITY: 3.7(a) Calculating gas volumes from the balanced equations:

What you need:

Calculator and notebook.

What to do: In groups

You will discuss on how to calculate the gas volumes from a balanced chemical Equation for the reaction that takes place. Share and compare your findings with the rest of the class.

Discussion Questions:

a) $100cm^3$ of nitrogen gas were reacted with $300cm^3$ of hydrogen gas at standard temperature and pressure, s.t.p during Haber process to produce ammonia gas. What was the volume of ammonia gas produced?

b) In the extraction of coals, it was found that $200cm^3$ of Sulphur dioxide gas was formed as a result of combustion with oxygen gas. Calculate the volume of oxygen gas used.

c) What volume of the gas remains unreacted when $80cm^3$ of hydrogen gas was allowed to react with $80cm^3$ of oxygen gas to form water?

d) $10dm^3$ of propane, C_3H_8 gas was burnt completely in excess oxygen gas to form water and carbon dioxide gas. Determine the volume of oxygen used during combustion.

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e) 300cm^{3}of nitrogen gas reacted with hydrogen gas to produce ammonia gas in large scale by Haber process at s.t.p. what volumes of ammonia gas were produced?

3.7.2. Calculating gas volumes when a gas (is formed from) reacts with a substance.

Worked out example 15

1. Calculate the volume of ethyne gas, C_2H_2 produced when 6.4g of calcium carbide, reacts with water at s.t.p. (Ar of Ca = 40, C = 12, H = 1; 1mole of a gas occupies 22.4l at s.t.p)

Possible answer:

Equation: $\mathbf{CaC_{2(s)} + 2H_2O_{(l)} \longrightarrow C_2H_{2(g)} + Ca(OH)_{2(s)}}$

Moles (1mole) (1mole)

RFM: CaC_2 =(40 + 12x2)

RFM: CaC_2 = 64

Alternative 1

So, (64x1)g of calcium carbide contain 1 mole.

6.4g of calcium carbide contains $\frac{6.4\ x1}{64}$ moles = 0.1moles

1mole of a gas occupies 22.4*l at* s.t.p

0.1moles of a gas occupies $\frac{22.4\ x\ 0.1}{1}\ l$ **= 2.24l of ethyne gas**.

Alternative 2

(64x1) g of calcium carbide contain 22.4 litres of a gas at s.t.p

6.4g of calcium carbide contain $\frac{6.4\ x\ 22.4}{64}$ litres of a gas at s.t.p

So, volume of ethyne gas, C_2H_2 at s.t.p is **2.24litres.**

2. Calculate the volume of oxygen gas evolved when 61.25g of potassium chlorate, $KClO_3$ was heated strongly until no further change. **(Ar of K =39, Cl =35.5, O =16 1mole of a gas occupies 24dm^3 at r.t.p)**

RFM: $KClO_3$ = (39 + 35.5 + 16x3) =122.5

Possible answer:

Equation: $\mathbf{2KClO_{3(s)} \longrightarrow 2KCl_{(s)} + 3O_{2(g)}}$

Moles: 2moles (excess) 3moles

Alternative 1:

(2x122.5) g of potassium chlorate contain 1mole.

61.25g of potassium chlorate contain $\frac{61.25\ x1}{2x122.5}$ moles = 0.25moles

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1mole of a gas occupies 24dm^3 at r.t.p

0.25moles of a gas occupies $\frac{24 \times 0.25}{1}$ dm^3 = **6dm^3 of oxygen gas produced**.

Alternative 2:

(2x122.5) g of potassium chlorate contain 24dm^3 of a gas at r.t.p

61.25g of potassium chlorate contain $\frac{61.25 \times 24}{2 \times 122.5}$ dm^3 of a gas at r.t.p

So, volume of oxygen gas produced at r.t.p is **6dm^3**

ACTIVITY:3.7(b) Calculating gas volumes when a gas reacts with (is formed from) a substance.

What to do: In groups

You will discuss on how to calculate the gas volumes when a gas is reacted with (formed from) a substance. Share and compare your findings with the rest of the class.

Discussion Questions:

a) Calculate the volume of hydrogen gas evolved when 6.5g of zinc granule react with dilute hydrochloric acid at s.t.p (Ar of Zn =65, 1mole of a gas occupies 22400cm^3 at s.t.p)
b) What volume of carbon dioxide gas is evolved when 50g of calcium carbonate was reacted with dilute hydrochloric acid? (Ar of Ca =40, C = 12, O =16, 1 mole of a gas occupies 24dm^3 at r.t.p)
c) Ammonium chloride sublimes when heated. 17g of ammonium chloride was heated producing hydrogen chloride gas and ammonia gas. Calculate the total volumes of the final gaseous products at s.t.p (Ar N =14, H =1, Cl =35.5, 1mole of a gas occupies 22.4dm^3)
d) Ammonium nitrate, NH_4NO_3 is atypical synthetic fertilizer derived from nitric acid. A sample of 31.5g of ammonium nitrate was heated strongly until there was no further change in a fume cup – board, ammonia gas and nitric acid fumes were produced. What was the volume of ammonia gas evolved at s.t.p. (Mr of NH_4NO_3 is 80g, 1mole of a gas occupies 22.4*l* at s.t.p)
e) 0.107g of ammonium chloride was heated with excess calcium hydroxide to form ammonia gas and calcium chloride and water.
(i) Write a balanced equation for the reaction that took place.
(ii) Calculate the volume of ammonia gas evolved at room temperature and pressure, r.t.p. (Ar of N =14, H =1, Cl =35.5, 1mole of a gas occupies 24dm^3 at r.t.p)
f) Glucose burns in oxygen according to the following equation.

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$ + Energy.

What is the volume of oxygen gas required to 150g of carbon dioxide gas at s.t.p. (Mr of CO_2 = 44g, 1mole of a gas occupies 22.4dm^3 at s.t.p)

g) Propene burns in oxygen according to the equation below.

$2C_3H_{6(g)} + 9O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$ + Energy.

h) **How much volume of carbon dioxide gas was produced at r.t.p when 2.1g of propene was burnt completely in air? (Mr of Propene =42g, 1mole of a gas occupies 24dm^3 at r.t.p)**

3.7.3. Calculating the mass of a substance from volumes of gases.

Worked out example 16

1. Hydrogen gas burns in oxygen to form steam according to the equation below.

   $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

   What mass of steam was formed at r.t.p when 300cm^3 of hydrogen is burnt in excess oxygen? (1mole of a gas occupies 24000cm^3 at r.t.p)

Possible answer (Alternative 1)

Equation: **$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$**

Moles: 2moles (excess) 2moles

24000cm^3 contain 1mole of a gas at r.t.p

300cm^3 contain $\frac{300 \times 1}{24000}$ moles of a gas at r.t.p

= 0.0125 moles of a gas at r.t.p

1 mole weighs 18g of steam

0.0125 moles weigh $\frac{18 \times 0.0125}{1}$g of steam

= **0.225g of steam**

RFM: H_2O = (1x2) + (16x1) =18

(**Alternative 2**)

24000cm^3 of H_2 produced a mass of 18g of steam

300cm^3 of H_2 produced a mass of $\frac{300 \times 18}{24000}$g of steam

= **0.0225g** of steam was produced

2. T is Sodium hydrogen carbonate used in bakery as baking powder to rise dough of bread. When this compound is heated, it decomposes according to the equation below:

   $2NaHCO_{3\,(s)} \longrightarrow Na_2CO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(l)}$

   What was the mass of sodium hydrogen carbonate used which gave 600cm^3 of carbon dioxide gas used to rise dough of breads at room temperature and pressure? (1mole of a gas occupies 24000cm^3 at r.t.p)

Possible answer (Alternative 1)

Equation: **$2NaHCO_{3\,(s)} \longrightarrow Na_2CO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(l)}$**

RFM of $NaHCO_3$ =

(23x1) + (1x1) + (12x1) +(16x3)

= (23+1+12+48) = 83 x2moles

= 83x2g = 166g

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Moles: 2moles 1mole.

$24000cm^3$ contain 1mole of a gas at r.t.p

$600cm^3$ contain $\frac{600\ x\ 1}{24000}$ moles of a gas at r.t.p

= 0.025 moles of a gas at r.t.p

1mole of weighs 166g of baking powder.

0.025moles weighs $\frac{166\ x\ 0.025}{1}$ g **= 4.15g of baking powder**

(Alternative 2)

$24000cm^3$ of **CO_2** evolved from a mass of 83x2g of T

$600cm^3$ of **CO_2** evolved from a mass of $\frac{600\ x\ 83x2}{24000}$g

= **4.15g** of baking powder

ACTIVITY: 3.7(c) Calculating mass of a substance from volumes of gases.

What to do: In groups

You will discuss on how to calculate the gas volumes can be used to calculate the mass of a substance. Share and compare your findings with the rest of the class.

Discussion Questions:

a) Magnesium ribbon reacts with steam when heated to form magnesium oxide and hydrogen gas according to the equation below:

(i) Write a well – balanced equation for the reaction.

(ii) What was the mass of magnesium ribbon used to produce $300cm^3$ of hydrogen gas? At room temperature and pressure, r.t.p.
(Ar of Mg =24, 1mole of a gas occupies $24dm^3$ at r.t.p)

b) Zinc carbonate was strongly heated to produce carbon dioxide and white solid left.

(i) Write an equation for the reaction that took place.

(ii) Calculate the mass of zinc carbonate used to produce $200cm^3$ of carbon dioxide gas at r.t.p. (Ar of Zn =65, C =12, O =16, 1mole of a gas occupies $24000cm^3$ at r.t.p)

3.7.4. Calculating the mass of a residue from mass of another substance.

Worked out example 17

1. Lead (II) carbonate decomposes when heated according to the equation below:

$PbCO_{3\,(s)} \rightarrow PbO_{(s)} + CO_{2\,(g)}$

What is the mass of the solid residue formed when 5.34g of lead (II) carbonate was heated. (Ar of: Pb =207, O =16, C =12)

Possible answer: (Alternative 1)

Equation: **$PbCO_{3\,(s)} \rightarrow PbO_{(s)} + CO_{2\,(g)}$**

Moles: 1mole produced 1mole (excess)

Mr: (207+ 12+ 16x3) (207 +16)

= 267g produced 223g of PbO

Mass: 5.34g produced $\frac{5.34\ x\ 223}{267}$ g of PbO

(Alternative 2)

267g of $PbCO_3$ produced 223g of PbO

5.34g of $PbCO_3$ produced $\frac{5.34\ x\ 223}{267}$g of PbO

Mass of lead (II) oxide produced is 4.46g

Mass of lead (II) oxide produced is 4.46g

ACTIVITY:3.7(d) Calculating the mass of residues from mass of another substance.

What to do: In groups

You will discuss on how the mass of residues can be calculated from the mass of another substance. Share and compare your findings with the rest of the class.

Discussion Questions:

a) Calculate the mass of lead (II) sulphate formed as residue when 17.8g of sodium sulphate solution was reacted with a solution of lead (II) nitrate.
(Ar of Na =23, S =32, Pb =207, O =16)

b) 4g Burning magnesium ribbon was lowered into a gas jar of carbon dioxide gas. The complete combustion of the reaction was according to the equation below:
$2Mg_{(s)} + CO_{2\,(g)} \longrightarrow 2MgO_{(s)} + C_{(s)}$
Calculate the mass of the solid residue formed after the burning stopped. ***(Mg =24, O=16)***

c) 8,5g of copper (II) carbonate was decomposed on heating until no further change occur to form copper (II) oxide and carbon dioxide gas.
What mass of the residue would be formed when 8.5g of copper (II) carbonate were heated? (Cu = 64, C =12, O =16)

Dr. Opio